

## MARLI: MARs Lidar for global climate measurements from orbit

Completed Technology Project (2017 - 2019)



## Project Introduction

We propose to design, build a breadboard, and demonstrate the key capabilities of a multifunctional atmospheric lidar (MARLI) for Mars orbit. This lidar will simultaneously measure atmospheric backscatter and depolarization profiles, wind profiles, and range from a near-polar circular orbit. These measurements address very high priority needs for Mars as summarized in the 2011 Planetary Decadal Survey. Knowledge of the present Mars atmosphere is severely limited by a lack of observations in several key areas including diurnal variations of aerosols and direct measurements of wind velocity. Both dust and water ice aerosols are pervasive in the Mars atmosphere. Dust interacts strongly with IR radiation causing large changes in the thermal structure and is a driver of atmospheric motions. Water ice clouds play an important role in the water cycle altering the global transport of water vapor. The limited local time coverage of observations to date has shown large changes in the amount and vertical distribution of dust and ice aerosols. However, existing observations do not allow the vertical distribution of the dust aerosols and ice to be characterized over the full diurnal cycle. Winds on Mars play a fundamental role, yet basic questions still remain about the 3-D wind structure and how it changes with local time, location, and season. Wind velocities provide sensitive input and validation for Global Circulation Models (GCMs), and knowledge of winds is important for the safety and precision of spacecraft entry, descent and landing (EDL). Despite their importance, presently there are only a few direct observations of winds on Mars, and indirect inferences are often imprecise. Because the Mars atmospheric dust cycle partially drive the wind fields, it is important to measure the dust and wind profiles simultaneously. It is ideal to measure them with the same instrument operating continuously, day and night, from a polar orbit. With support from an award from the Picasso program, we are presently developing a breadboard of a wind profiling lidar (called MARLI) to meet these needs. To date we have made considerable progress by: (a) leveraging the design of a single-frequency pulsed Nd:YAG laser from one now flying on CATS/ISS; (b) using a single solid etalon as a frequency resolver in the direct detection receiver, and (c) utilizing a highly sensitive 16-element HgCdTe APD detector from the ESTO IIP-10 program. We now we are assembling the instrument breadboard for measurement demonstrations. We have also updated our lidar performance/SNR models, which show better measurement performance than originally predicted. We plan to exit the Picasso program with the approach demonstrated from the ground, and accurate instrument performance model. The key components have TRLs from 3-5. For Mars we now have two approaches: one that measures along a single line of sight, allowing unidirectional measurements, as well as a dual beam/dual telescope approach that allows full vector measurements. Our approach is also flexible in wavelength and allows adding a frequency converter assembly to the laser. By operating at 2030 nm in the Titan atmosphere's optical transmission window, this also allows measuring wind and aerosol backscatter profiles in the Titan atmosphere from orbit. Our planned work for MATISSE includes (a) further



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## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Responsible Program:**

Maturation of Instruments for Solar System Exploration

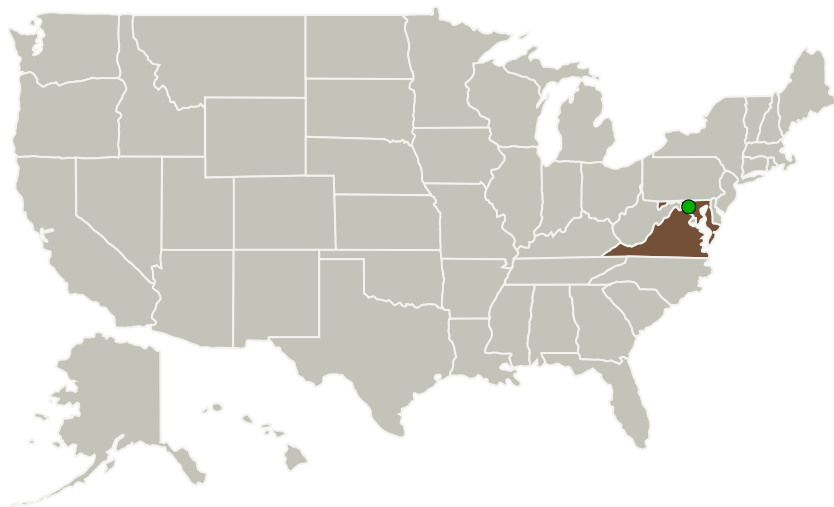
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engineering the breadboard instrument into a brassboard, (b) demonstrating wind measurements (scalable to those from Mars orbit) to thin cirrus clouds from the ground, (c) and taking the key instrument assembly, the laser/telescope/receiver assembly, through vibration and TVAC tests. We will also demonstrate a version at 2030 nm for Titan and make wind measurements from the laboratory. We plan to propose a period of performance of 2 years, starting in April 2017. The component average Entry TRL is 4, and the Exit TRL of the key components will be 6.

## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
 Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Maryland	Virginia

## Project Management

**Program Director:**

Carolyn R Mercer

**Program Manager:**

Haris Riris

**Principal Investigator:**

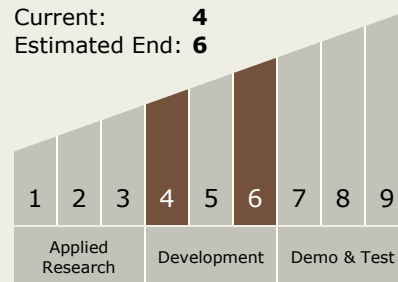
James B Abshire

**Co-Investigators:**

Anand Ramanathan  
 Graham R Allan  
 Scott D Guzewich  
 Bruce M Gentry  
 Michael D Smith  
 David T Leisawitz  
 Floyd E Hovis  
 Oliver Reitebuch  
 Haris Riris  
 Conor A Nixon  
 Xiaoli Sun

## Technology Maturity (TRL)

Start: 4  
 Current: 4  
 Estimated End: 6



## Technology Areas

**Primary:***Continued on following page.*



## Technology Areas (cont.)

- TX08 Sensors and Instruments
  - └ TX08.1 Remote Sensing Instruments/Sensors
    - └ TX08.1.5 Lasers

## Target Destination

Others Inside the Solar System